

## **TMM027 – INTRODUCTION TO LOGIC** (December 9, 2022)

### **Suggested Number of Credit Hours: 3**

This is a general education course in formal logic for students not needing a more specialized course in mathematics or for students whose major area of study benefits from the study of formal logic such as philosophy majors, pre-law majors, math majors, computer science majors, and engineering majors. This course introduces students to the study of logic in general and specifically introduces students to the formal study of deductive logic. Topics include identifying arguments and their parts, evaluating arguments for validity or strength, drawing and interpreting Venn diagrams, constructing and interpreting truth tables, formal proof rules and techniques, and defining and applying logical concepts such as consistency, logical equivalency, and so on.

To qualify for TMM027 (Introduction to Logic), a course must meet all the outcomes for the two essential topics (marked with an asterisk) and at least one set of outcomes for one of the two alternate topics. In other words, courses must not only meet all the outcomes for basic logical concepts and skills and sentential logic but also must either meet the outcomes for predicate logic or the outcomes for categorical logic. Courses primarily concerned with critical thinking in general do not qualify. At least 70% of course time should be spent on the essential and alternate topics.

Course topics fit the material in the following common logic texts:

Bergmann, Moor, and Nelson, *The Logic Book*, 6<sup>th</sup> Ed.

Essential: Chapters 1, 2, 3, and 5

Alternate: Chapter 10

Copi, Cohen, and Rodych, *Introduction to Logic*, 15<sup>th</sup> Ed.

Essential: Chapters 1, 2, 8, and 9

Alternate: Chapters 5, 6, and 7 OR Chapter 10

Hurley and Watson, *A Concise Introduction to Logic*, 13<sup>th</sup> Ed.

Essential: Chapters 1, 6, and 7

Alternate: Chapters 4 and 5 OR Chapter 8

1. **Basic Logical Concepts and Skills (Essential Topic)** – Successful students are able to define and apply concepts from logic.
  - 1.1 Define “statement”. Identify statements. \*

**Sample Task:** Determine which of the following are statements.

- Look out!
- There’s a duck in that pond.
- I think the Bengals will win the Super Bowl next year.

- How far is it from Columbus to Cincinnati?
- Hand me the relish please.
- Dogs are reptiles.
- Cake is a better desert than ice cream.

- 1.2 Define “argument” (including “premise” and “conclusion”). Identify arguments, their premises and conclusions, and write arguments in standard form. \*

**Sample Task:** Write the following argument in standard form.

Prof. Plumb’s fingerprints were on the candlestick and Mr. Body died from blunt force trauma. So, Prof. Plumb is guilty – especially since several eyewitnesses saw them arguing feverishly in the billiard room.

- 1.3 Define “logically true” (or “tautology”), “logically false” (or “self-contradictory”), and “contingent”. Classify individual statements as logically true, false, or contingent. \*

*Note:* This could be done alongside teaching the use of truth tables in sentential logic. See 2.4 for sample tasks.

- 1.4 Define “equivalent” and “contradictory”. Classify pairs of statements as equivalent or contradictory. \*

*Note:* This could be done alongside teaching the use of truth tables in sentential logic. See 2.5 for sample tasks.

- 1.5 Define “consistent” and “inconsistent”. Classify sets of statements as consistent or inconsistent. \*

*Note:* This could be done alongside teaching the use of truth tables in sentential logic. See 2.6 for sample tasks.

- 1.6 Describe the difference between deductive and inductive arguments. Classify arguments as deductive or inductive. \*

**Sample Task:** For each of the following arguments, determine if it is inductive or deductive.

- The universe is complex and purposeful, like a machine. Therefore, like a machine, it has a designer.
- All humans are mortal. Hypatia is a human. Consequently, Hypatia is mortal.
- A random sample of 2,000 Americans, 85% said they like the direction the country is heading in. So, a majority of Americans like the direction the country is heading in.

- Bill has \$4. Marcia has \$3. So, together they have \$7.
- Ms. Scarlet confessed to murdering Mr. Body. Therefore, Ms. Scarlet is guilty.
- If ostriches are birds, then they can't fly. They can't fly. So, they aren't birds.

1.7 Define "valid" and "sound". Evaluate arguments for validity and soundness. \*

**Sample Task:** For each of the following deductive arguments, determine whether it is valid and sound. Explain your answer.

- Tokyo is in Argentina. Argentina is south of the equator. Therefore, Tokyo is south of the equator.
- Meerkats are mammals and mammals are warm-blooded. Therefore, meerkats are warm-blooded.
- If Superman is Clark Kent, then Batman is Bruce Wayne. Batman is Bruce Wayne. Therefore, Superman is Clark Kent.

1.8 Define "strong" and "cogent". Evaluate arguments for strength and cogency. \*

**Sample Task:** For each of the following inductive arguments, determine whether it is strong and cogent. Explain your answer.

- Many people have seen geese flying south. So, it is likely that geese are migratory birds.
- The Pythagorean theorem is named after Pythagoras. So, it is extremely probable that he was the first person to think of it.
- In recorded history, Florida has never been hit by a hurricane in February. So, Florida won't be hit by a hurricane next year in February.
- 90% of Americans are vegetarians. Michelle Obama is an American. It follows that she's probably a vegetarian.

1.9 Explain relationships between logical concepts. \*

**Sample Task 1:** Suppose the premises of an argument are inconsistent. Will the argument be valid, invalid, or is that something that can't be determined based on this information alone? Explain your answer. If your answer is "can't be determined" provide an example of an argument with inconsistent premises that is valid and an example with inconsistent premises that is invalid.

**Sample Task 2:** Suppose that two statements are logically equivalent. Will they be consistent, inconsistent, or we can't determine this? If your answer is "we can't determine this" provide an example of a pair of statements that are logically equivalent and consistent and an example of a pair that is logically equivalent but inconsistent.

2. **Sentential/Propositional Logic (Essential Topic)** – Successful students demonstrate competency understanding and using sentential logic.

2.1 Translate English statements into sentential logic and vice versa. \*

**Sample Task:** Write each of the following statements in sentential logic.

- George is at school if and only if it isn't a snow day.
- If either there's rain or snow in the forecast, then we can't go camping; but, we can if it is forecast to be sunny.
- It is not the case that if neither the CPI rises nor the Dow Jones drops then not both the Fed will not raise interest rates and oil imports will double.

2.2 Identify the main operators of complex statements. \*

**Sample Task:** For each of the following, determine if it is a well-formed formula and, if it is, what the main operator is.

- $A \& B \vee C$
- $K \rightarrow (J \vee W)$
- $\sim(H \rightarrow \sim Q) \vee \sim G$
- $\sim[(A \vee \sim B) \leftrightarrow (C \& \sim A)]$

2.3 Calculate the truth value of a complex statement based on the truth values of its component atomic statements. \*

**Sample Task:** Assume A and B are true, Y and Z are false, and the truth values of P and Q are not known. If possible, determine the truth values of each of the following:

- $\sim A \rightarrow Y$
- $Q \vee \sim Z$
- $(P \rightarrow A) \& \sim (Y \rightarrow B)$
- $\sim[(Z \& B) \vee (\sim A \vee Q)]$

2.4 Construct truth tables for individual complex statements and use those to classify statements as logically true, logically false, or contingent. \*

**Sample Task:** For each of the following, construct a truth table to determine if the statement is logically true, logically false, or contingent. Explain your answer.

- $A \vee \sim A$
- $\sim(B \rightarrow K)$
- $(Q \& \sim R) \& (Q \rightarrow R)$

2.5 Construct truth tables for pairs of complex statements and use those to classify the pairs as equivalent or contradictory. \*

**Sample Task:** For each of the following pairs, construct a truth table to determine if the statements are equivalent, contradictory, or neither. Explain your answer.

- $\{\sim X \vee Y, X \rightarrow Y\}$
- $\{W \rightarrow Q, W \rightarrow \sim Q\}$
- $\{(P \rightarrow Y) \& (Y \rightarrow P), \sim(Y \leftrightarrow P)\}$

2.6 Construct truth tables for sets of complex statements and use those to classify the sets as consistent or inconsistent. \*

**Sample Task:** Construct a truth table to determine if the following set of statements is consistent or inconsistent. Explain your answer.

$\{H \rightarrow \sim(G \& W), (G \vee H) \leftrightarrow W, \sim[G \vee (W \& \sim H)]\}$

2.7 Construct truth tables for arguments and use those to evaluate arguments for validity. \*

**Sample Task:** Construct a truth table to determine if the following argument is valid or invalid. Explain your answer.

$J \leftrightarrow \sim K \quad / \quad K \& Q \quad // \quad \sim(Q \rightarrow J)$

2.8 Construct derivations using direct proof techniques. \*

**Sample Task:** For each of the following, use the rules of natural deduction to derive the conclusion from the premises.

1.  $K \vee B$
2.  $\sim(J \vee K)$
3.  $B \rightarrow (X \leftrightarrow J) \quad / \quad \sim X$

1.  $K \& (\sim Z \rightarrow \sim Q)$
2.  $(H \rightarrow B) \& (B \rightarrow Q)$
3.  $\sim H \rightarrow \sim K \quad / \quad Z$

2.9 Construct derivations using indirect proof techniques. \*

**Sample Task:** Use an indirect proof to complete the following derivation.

1.  $J \rightarrow (A \& \sim B)$
2.  $A \rightarrow B$  /  $\sim J$

2.10 Construct derivations using conditional proof techniques. \*

**Sample Task:** Use a conditional proof to complete the following derivation.

1.  $J \rightarrow (Q \vee Z)$
2.  $J \rightarrow (W \vee X)$
3.  $\sim(Z \vee X)$  /  $J \rightarrow (Q \& W)$

2.11 Construct derivations to show an individual statement is logically true. \*

**Sample Task:** Use conditional proof or indirect proof to show that the following statement is logically true.

$$(A \rightarrow \sim B) \leftrightarrow (\sim B \vee \sim A)$$

3. **Predicate Logic (Alternate Topic)** – Successful students gain competency with predicate logic.

3.1 Translate English statements into predicate logic and vice versa.

**Sample Task:** Translate each of the following into predicate logic.

- All chimpanzees are primates.
- Somebody murdered Mr. Body.
- If Barack Obama was born in Hawaii, then he's an American citizen by birth and eligible to run for President.
- Either no soft drinks contain caffeine or some do.
- It is not the case that every good boy does fine.

3.2 Construct derivations in predicate logic.

**Sample Tasks:** Complete the following derivations.

1.  $(x)(Ax \rightarrow Bx)$
2.  $(x)(Bx \rightarrow Cx)$  /  $(x)(Ax \rightarrow Cx)$
  
1.  $(\exists x)Qx$
2.  $(x)(Qx \leftrightarrow Bx)$
3.  $(\exists x)(Bx \& Qx) \rightarrow \sim Ba$  /  $(\exists x)\sim Bx$
  
1.  $(x)(Jx \vee Mx)$
2.  $\sim(\exists x)Jx$  /  $(x)Mx$

4. **Categorical Logic (Alternate Topic)** – Successful students gain competency with categorical logic.

4.1 Identify the components of categorical propositions (quantifier, subject, copula, and predicate).

**Sample Task:** For each of the following, identify the quantifier, subject, copula, and predicate.

- All leafy greens are healthy vegetables.
- Some traditional breakfast foods are hazards for heart health.
- No quaint cul-de-sacs are grand boulevards.
- Some superheroes are not beings with superpowers.

4.2 Identify the logical properties of categorical propositions (quality and quantity).

**Sample Task:** For each of the following categorical propositions, identify the subject, predicate, quantifier, and copula and determine the quality and quantity.

- Some green snakes are constrictors.
- No elm trees are conifers.
- Some great books are not controversial novels.
- All tourists are people who need a break.

4.3 Formalize English statements as standard-form categorical propositions.

**Sample Task:** Write each of the following as a standard-form categorical proposition.

- Many goldfish are small.
- Venus is the evening star.
- Everyone likes chocolate.
- Nobody lives on Mars.

4.4 Apply contradiction, obversion, conversion, and contraposition to categorical propositions.

**Sample Task:** For each of the following, write its contradiction, obverse, converse, and contrapose.

- Some large boulders are dangerous rocks.
- No creaky stairs are structural problems.
- All lucky gamblers are unlikely heroes.
- Some true statements are not universal statements.
- No V are non-W.

- Some non-X are non-G.
- Some non-J are H.
- All B are C.

4.5 Use contradiction, obversion, conversion, and contraposition to evaluate the validity of immediate inferences.

**Sample Task:** For each immediate inference below, determine how the premise and conclusion are related (contradiction, obversion, conversion, or contraposition) and also if the argument is valid.

- Some college students are vegetarians. Therefore, some college students are not people who eat meat.
- No parakeets are large birds. Therefore, no large birds are parakeets.
- Some electric vehicles are not self-driving cars. Therefore, it is false that all electric vehicles are self-driving cars.
- All sugary drinks are unhealthy beverages. Therefore, all healthy beverages are sugar-free drinks.
- It is false that some firetrucks are big rigs. Therefore, no firetrucks are big rigs.
- It is false that all carbon emitters are powerplants. Therefore, it is false that no carbon emitters are things other than powerplants.

4.6 Draw Venn diagrams for categorical propositions.

**Sample Task:** Draw a Venn diagram for each of the following statements.

- Some dancers are not bowlers.
- No olive trees are arctic plants.
- All carnivorous plants are insectivores.
- Some cumulous clouds are storm clouds.

4.7 Use Venn diagrams to evaluate the validity of immediate inferences.

**Sample Task:** Use a Venn diagram to evaluate the validity of the following immediate inference.

It is false that some architects are art collectors. Therefore, some architects are not art collectors.

4.8 Identify the components of categorical syllogisms (major term, minor term, and middle term).

**Sample Task:** Identify the major, minor, and middle terms in the following syllogism.

Some television actors are not celebrities because no television actors are conductors, and some conductors are celebrities.

4.9 Put categorical syllogisms in standard form.

**Sample Task:** Put the following syllogism in standard form.

No G are H. Therefore, some G are not B since all B are H.

4.10 Identify the mood and figure of categorical syllogisms.

**Sample Task:** Identify the mood and figure of the following standard form syllogism.

All J are K.

Some W are K.

Some W are not J.

4.11 Use Venn diagrams to evaluate the validity of categorical syllogisms.

**Sample Task:** Put the following argument in standard form, reducing terms where necessary, and use a Venn diagram to determine its validity.

Some bankers are lawyers since no lawyers are unwealthy people and some wealthy people are not people who don't work at banks.

4.12 Evaluate enthymemes and sorites.

**Sample Task 1 (enthymeme):** Determine what premise, if any, would make the following argument valid.

Some pets are not reptiles. Therefore, some pets are not lizards.

**Sample Task 2 (sorites):** Put the following sorites in standard form reducing terms where necessary. Then determine the intermediate premises/conclusions (if any) and evaluate it for validity.

Some J are Q.

All non-K are non-W.

No Y are non-Q.

All K are J.

Some Y are not W.